Mobile Future
Wireless. Innovation. Freedom.

May 12, 2010

Via ECFS
Marlene H. Dortch, Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: Notice of ex parte presentations
GN Docket No. 09-191; WC Docket No. 07-52

Dear Ms. Dortch:

Pursuant to the Commission's rules, this is to report ex parte meetings in the above-referenced dockets. On May 11, 2010, Mobile Future met in separate meetings with Louis Peraertz of the office of Commissioner Mignon Clyburn, and Charles Mathias and Henry Gola of the office of Commissioner Meredith Attwell Baker. In both of these meetings, Mobile Future was represented by Jonathan Spalter, Chairman; Ari Fitzgerald, Advisory Board member; the undersigned; and consultant Peter Rysavy of Rysavy Research, LLC. On May 12, 2010, Mobile Future met with the following staff of the Office of Engineering and Technology: Julius Knapp, Chief; Alan Stillwell, Deputy Chief; Geraldine Matise, Policy and Rules Division Chief; Walter Johnson, Electromagnetic Compatibility Division Chief; and James Miller. In this meeting, Mobile Future was represented by Ari Fitzgerald, Advisory Board member; Brian Fontes, Advisory Board member and CEO of the National Emergency Number Association (NENA); the undersigned; and consultant Peter Rysavy of Rysavy Research, LLC.

The purpose of all three meetings was to discuss the engineering constraints unique to wireless broadband networks that require that the operators of such networks have maximum flexibility to engage in effective network management. Mobile Future's presentation included the attached slides, which were distributed to the attendees, as well as the attached paper by Mr. Rysavy, "Traffic Management and Network Layering." Please include both of these documents in the record of these proceedings.

Sincerely,

/s/

Allison Remsen
Executive Director

Attachments
cc: FCC attendees (via email)

Traffic Management and Network Layering

By Peter Rysavy, Rysavy Research
http://www.rysavy.com

WA DC, May 12, 2010

Agenda

- Benefits of a network model.
- Correspondence of network model to TCP/IP.
- Interaction between layers.
- The need to manage wireless networks using all layers.
- Different management strategies for wireline networks.

This presentation is based on the Rysavy Research paper "Traffic Management and Network Layering"

OSI Network Reference Model

Open Systems Interconnection

Developed in the 1970s by the International Standards Organization.

Only roughly corresponds to TCP/IP layering.

Layer	
Application	Top 3 layers combined in TCP/IP as application layer.
Presentation	
Session	
Transport	Reliable end to end connection.
Network	Routes packets from source to destination.
Data Link	Raw bit stream of physical layer framed.
Physical	Mechanical, electrical interfaces.

Model Details Layer 4 to 7

Layer	Function	Wireline	Wireless
5 to 7	Application	E.g., e-mail, Web	Similar to wireline
4	End-to-end, e.g., TCP/UDP	Most applications use TCP or UDP	TCP/UDP common, TCP fails under congestion, wireless specific transports

Model Details Layer 1 to 3

Layer	Function	Wireline	Wireless
3	Network layer, e.g., IP	All Internet uses IP	Most modern wireless uses IP
2	Link layer for point-to-point and access, varies by network	Many different protocols	Extremely sophisticated methods needed
1	Physical layer, the medium	Wire or fiber	Modulation and coding

Interaction Between Layers

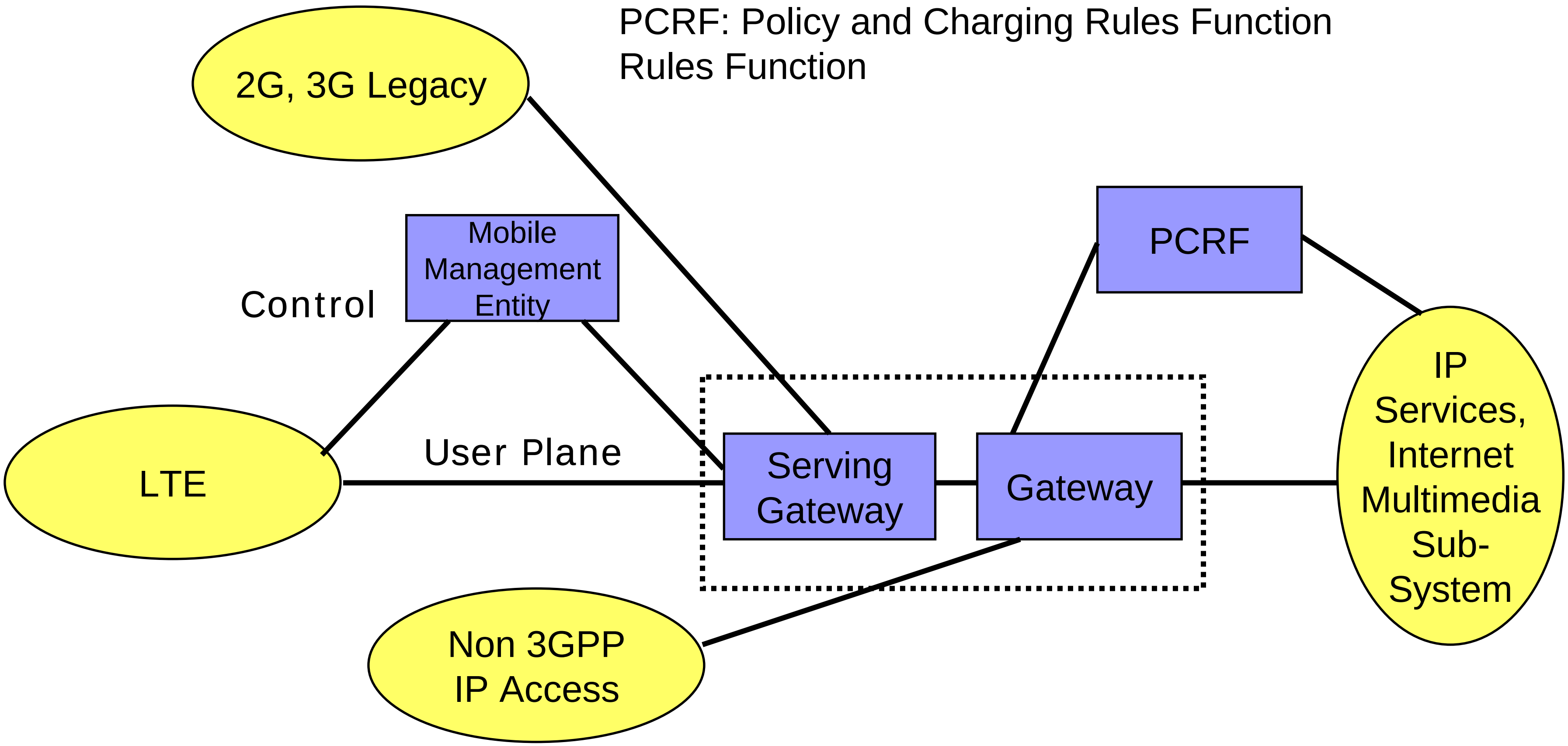
- Layers supposed to be independent, but …
- Under congestion:
  - Packet delays, dropped packets.
  - Causes TCP retransmissions and ultimately application failure.
- Much more likely with wireless than wireline.
- Signaling traffic
  - E.g., Session Initiation Protocol (SIP).
  - IP-based but controls traffic streams.

Need to Manage All Layers

Need	Wireless
Congestion Management	Need to deprioritize certain traffic flows. Can be per clearly articulated service plans. Network needs to be cognizant of application type. Congestion less likely to occur on wireline network.
QoS Control and Traffic Management	3GPP option of Policy and Charging Control (PCC). Control of throughputs, delays, priority. Benefits multimedia. Requires application awareness. Essential for very operation of new IP-based core networks. Due to complexity, less likely to be deployed on wireline networks.
Service Plan Flexibility	Creative plans that enable/disable selective applications.

QoS-Enabled Networks with Dynamic Policy

EPC: Evolved Packet Core
LTE: Long Term Evolution
PCC: Policy and Charging Control
PCRF: Policy and Charging Rules Function
Rules Function



Conclusion

- Wireless networks do require specific management approaches at lower layers.
- Helps address interference and achieve high spectral efficiency.
- But network management does not stop at layer two.
- Network management will involve all network layers.
- Wireline networks do not face the same constraints, and are unlikely to need these mechanisms.

Traffic Management and Network Layering

May 10, 2010

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Table of Contents

Introduction

This objective of this paper is to explain why wireless operators need to implement network and traffic management approaches that involve all layers of the networking model. Some[1] have argued that wireless networks are fundamentally different from wired networks only at and below the network layer and that therefore wireless network operators are not justified in implementing different traffic management practices at higher layers compared to wireline networks.

While this approach sounds reasonable, it fails to take into account that the likelihood of congestion on wireless networks due to limited capacity is much greater than on wireline networks. In fact, wireless operators are likely only to be successful in supporting the greatest range of applications for the greatest number of users if their management approaches integrate all layers. These approaches are likely to differ significantly from approaches used by wireline network operators.

Understanding the Network Layer Model

In the 1970s the International Standards Organization (ISO) developed a networking model called Open Systems Interconnect (OSI). This model divides operation into independent layers, which simplifies network implementation and provides considerable flexibility in how networks are deployed. This model was developed in conjunction with the OSI networking protocols and only roughly corresponds to today's Internet protocol layering.

With respect to wireless networks, the lowest two layers are generally the ones that are the most wireless specific, but as we argue, all layers are impacted by the wireless medium. The following table summarizes the model, explains how it pertains to today's Internet protocols, and comments on wireline versus wireless implementation.

Table 1: OSI Model and How it Applies Internet Protocols, Wireline, and Wireless

OSI Layer	Function	Wireline	Wireless
Layers 5 to 7	Application layer functions as well as presentation and session layers.	User applications such as e-mail and Web browsing.	Generally the same as for wireline networks.
Layer 4	Transport layer for end-to-end communications. Implemented in the Internet by Transmission Control Protocol (TCP) and User	Most applications use TCP or UDP. (VoIP uses UDP in combination with other transport	Many applications use TPC and UDP, but TCP tends to fail in congestion situations. Mobile-specific

[1] For example, see Scott Jordan, University of California, Irvine, "Do wireless networks merit different net neutrality than wired networks," April 9, 2010.

OSI Layer	Function	Wireline	Wireless
	Datagram Protocol (UDP)	protocols.)	transport protocols offer greater reliability.
Layer 3	Network layer for routing through the network. Implemented by the Internet Protocol (IP).	All Internet applications are based on IP.	All modern wireless networks support IP communication and most data applications operate using IP.
Layer 2	Link layer for point-to-point communications. Varies by network.	Many different link-layer protocols used based on type of medium used.	Wireless networks employ extremely sophisticated link-layer methods.
Layer 1	Physical layer. The medium used.	Wire or fiber.	Radio-frequency modulation and coding.

What one can conclude from the table is that wireless networks and wireline networks look very similar from layer 3 and upward. This is one reason that mobile broadband networks have been so successful: namely there is a wealth of Internet applications that can operate over wireless connections.

But what must be understood is that the transport (e.g., TCP) and application layers only function reliably when the lower layers can deliver packets reliably and quickly. With increasing load on a network, packet delays keep increasing until higher-layer protocols time out. This results in effects such as the transport layer having to retransmit packets, forcing additional delays. In these situations, applications can become sluggish and ultimately application-layer protocols can time out leading to application failures. The same can occur on wired networks, but is much more likely to occur on wireless networks.

Therefore, though the different layers are logically independent, under adverse conditions the inability of lower layers to work properly results in poor operation at higher layers. The only way for wireless operators to manage capacity constraints is through approaches that involve all the layers of traffic.

Another way that different layers interact with each other is with signaling traffic. As networks move to an all IP-architecture, signaling (control) protocols will operate above the IP layer. A good example is Session Initiation Protocol (SIP), a protocol used to set up VoIP calls that are then carried using separate transport protocols. SIP operates above the IP layer, but it has a direct effect on other traffic streams.

Wireless Versus Wireline Networks

Before considering network management, it is worth summarizing the key differences between wireless and wireline networks.

1. **Shared network.** In wireless networks, large numbers of subscribers have to share the data channels across a sector coverage area. Wireline access networks can have some element of sharing, but usually it is over a small number of subscribers and the service provider has far greater flexibility in augmenting capacity.

~~1.~~2. **Different layers 1 and 2.** Wireless networks clearly need management approaches that differ from wireline networks. For example, wireless scheduling involves control over which user at any moment, based on instantaneous radio conditions, should send or receive packets. Radio links are designed to use dynamic modulation and data encoding to address varying radio conditions and interference. The result is a wide range of actual throughput rates, which can affect higher level layers such as transport-layer protocols and application protocols.

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~~1.~~3. **Mobility.** Users can move from one coverage area to another. This presents a varying load on the network mandating additional management approaches.

~~1.~~4. **Constrained Capacity.** Wireless networks have far less capacity than wireline networks. Available capacity must be managed extremely carefully.[2]

Managing Wireless Networks

Given these differences, wireless operators will need to manage their wireless networks in ways that involve all the networking layers including the application layer and will need to do so in ways that are likely to differ from wireline networks.

There are multiple reasons for this. Examples include the need to manage severe congestion situations that are unpredictable, the need to implement quality-of-service tools so that wireless delivery of video and other services can compete with their wired brethren, and the need to offer more flexible service plans to more customers. All these consumer-oriented objectives will be driven by constrained capacity, and all are much less likely to be used in wireline networks.

Severe Congestion Situations

The capacity in any coverage area is extremely finite. For example, even in LTE deployed in 20 MHz (10 MHz forward channel + 10 MHz reverse channel), based on a spectral efficiency of 1.5 bps/Hz,

[2] For more details, refer to the report from Rysavy Research, “Mobile Broadband Capacity Constraints and the Need for Optimization,” February 16, 2010, http://www.rysavy.com/Articles/2010_02_Rysavy_Mobile_Broadband_Capacity_Constraints.pdf.

the sector downlink capacity is only 15 Mbps.[3] There are various applications that are extremely bandwidth intensive, such as peer-to-peer file sharing and video. Typical video streaming rates range from 500 kbps to 2 Mbps. It only takes a handful of users to consume the entire radio channel. Yet for e-mail and non-streaming oriented Web browsing, 15 Mbps of capacity could support hundreds of users. If all users are provided equal access, the result will be that a small number of users will be able to adversely affect everybody's experience. Keep in mind that today's 3G technologies only have half the data spectral efficiency of LTE, making congestion even more likely on today's 3G networks. (If there is voice loading on the 3G network, or if traffic consists of smaller messages, spectral efficiency is even lower.)

Based on clearly articulated service-plan provisions, however, operators could allow massively bandwidth-consuming applications to operate normally when capacity is available. But in congestion situations when there are many other users trying to use the network, the operator could assign the high-load applications a lower priority, thus providing an improved experience for the largest possible number of users. Such mechanisms will operate by network management that involve the application layer. In other words, for many situations, the network must be cognizant of the applications being used to manage traffic.

Quality of Service and Bandwidth Management

With constrained capacity, wireless operators are more likely to implement QoS mechanisms with which they can manage traffic flows across radio channels. These QoS mechanisms frequently are based on what kind of application is involved (such as VoIP, video streaming, etc.)

For example, network technologies such as High Speed Packet Access (HSPA) and Long Term Evolution (LTE) provide for a capability called Policy Charging and Control (PCC). PCC allows for implementation of policies that result in the control of what radio resources are available to users based on both their service plans and the applications they use. QoS parameters include throughput rates, packet delays, and priority. Voice and media-oriented applications will benefit significantly from use of QoS.

In order to provide QoS to different users and services, the network must be aware in many cases of the application in use, and therefore must consider application and other higher layer protocols. Similarly, when a new application is initiated by the user, the application can be set up with a particular level for QoS for that service. The operator could, for example, offer a service option that applies QoS to certain video applications of the users choice to improve the user experience.

[3] For a detailed discussion of spectral efficiency of different wireless technologies, refer to page 54 of the report from Rysavy Research, "HSPA to LTE-Advanced", September 2009. http://www.rysavy.com/Articles/2009_09_3G_Americas_RysavyResearch_HSPA-LTE_Advanced.pdf.

Note also that implementation of QoS will be an essential element for making core operator infrastructure work correctly. For example, IP-based signaling traffic (e.g., SIP) in the IP Multimedia Subsystem (IMS) must operate with suitable priority to enable key IMS-based services. Without this capability, operators will not be able to migrate their voice service to IP.

Implementing QoS is quite complex. This is why it has not been implemented in the Internet in which operation is instead on a best-efforts basis. The reason applications such as Skype work as well as it does is that there is sufficient capacity in all the links on an end-to-end basis that packets do not get queued and delayed by network elements. In contrast, Skype is unusable today on congested 3G networks.

Service Plan Flexibility

Given constrained capacity, wireless customers might wish to choose services plans that are only provisioned for the applications they have selected. Using the same policy management systems described in the prior section, operators will be able to offer service plans that selectively disable or enable different applications. For example, some subset of users might well be interested in a lower-cost plan where the network automatically blocks high-bandwidth applications such as video. This form of network management again involves application-level management.

Another example of service plan flexibility is where a discounted service plan would employ data transcoding. A high-bandwidth video stream potentially has much greater resolution than can even be depicted on a phone with its much smaller screen. By transcoding the stream to a lower resolution, the operator could dramatically reduce the amount of bandwidth consumed with no discernible effect to the user. This can be considered a layer six (presentation) function in the OSI model, or simply the application layer in TCP/IP networking.

Again, this kind of approach is extremely unlikely for wireline networks, first because the bandwidth constraints do not exist, and second because users are not plugging their iPhones into wireline networks.

Conclusion

This paper has discussed that it is true that wireless networks require specific management approaches at layers one and two of the OSI network model to account for the unique characteristics of radio communications, to deal with issues such as interference, and to employ methods such as efficient scheduling of the radio resource in order to achieve high spectral efficiency.

But this paper has also shown that network management does not stop at layer two. There will be many circumstances such as congestion management, QoS implementation, prioritization of critical control traffic, and service plan flexibility, that will mandate network management at higher layers. Because wireline networks do not face the same capacity constraints as wireless networks, it is much less likely that they will need to employ these mechanisms.

If operators are unable to manage their data traffic in a manner that encompasses all levels of the network model, there will be a number of unfortunate consequences. They may not be able to migrate various services, including voice, to all IP-architectures (the very essence of networks such as LTE and WiMAX) because they will not be able to prioritize critical control traffic that runs at higher layers. They will not be able to incent users to use available capacity efficiently and selectively, resulting in a best-efforts mode of operation where applications function inconsistently . Finally, operators will be discouraged from creating innovative new services that would help continued market development and expansion.